

## CLINICAL SCIENCE

# The effects of one-half of a soccer match on the postural stability and functional capacity of the lower limbs in young soccer players

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**OBJECTIVE:** Most injuries occur during the final 15 minutes of each half of a soccer match, suggesting that physical exertion may influence changes in neuromuscular control and the body's ability to stabilize the joints of the lower extremities. The aim of this study was to analyze the effects of one-half of a soccer match on the functional capacity and stability of the lower limbs in young soccer players.

**METHODS:** We analyzed 27 soccer players by evaluating the functional capacity of their lower limbs using the hop test protocol and their level of postural stability using the Biodex Stability System. The evaluations were performed before and after 45 minutes of game time.

**RESULTS:** After the match, there was a decrease in the overall stability index (OSI) ( $F_{(1,23)} = 5.64, p = 0.026$ ) and the anterior-posterior stability index (APSI) ( $F_{(1,23)} = 5.24, p = 0.032$ ). In the single and triple hop tests, there was a higher functional capacity in the dominant limb compared to the non-dominant limb in the pre- and post-game comparisons.

**CONCLUSION:** The results of this study show that there is a decrease in the stability of the lower limbs in young soccer players after a 45 minutes soccer match, but the same result was not found for the functional capacity.

**KEYWORDS:** Postural Stability; Soccer; Injury; Balance.

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## INTRODUCTION

Soccer is considered to be the most popular sport in the world. This sport currently has approximately 200,000 professional athletes and 240 million amateur players, of whom approximately 80% are male (1,2).

Youth participation in soccer is very important in current public health programs because it increases the level of exercise and physical activity of young people. Thus, soccer is a key tool in the fight against the high rates of childhood obesity and a sedentary lifestyle (3).

Soccer is among the fastest growing sports in terms of the number of young players worldwide. However, there has also been an increase in the number of injuries related to this sport among young athletes; approximately 44% of soccer

injuries occur in participants younger than 15 years of age (4). In the United States, soccer injuries among young athletes have peaked at 2 injuries per 1,000 participants (5).

Most injuries occur in the final 15 minutes of each half of a soccer match, suggesting that physical exertion may influence changes in neuromuscular control and the ability to stabilize the joints of the lower limbs. One possible hypothesis for this shift could be a change in the postural stability of the lower limbs due to physical exertion (6,7).

It has been theorized that muscle fatigue may alter the proprioceptive and kinesthetic properties of joints by increasing the threshold for muscle spindle firing, disrupting the afferent feedback and changing the somatosensory input, thus causing deficits in neuromuscular control. These characteristics can be visualized by the lack of postural control (6). Postural stability is a complex process that depends on proprioceptive stimuli from mechanoreceptors and vestibular and visual receptors. All of these signals are processed in the central nervous system to generate an appropriate motor response (6).

Previous studies have investigated the effects of physical exertion on the functional stability and proprioception of the

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lower limbs in athletes. However, most of these studies used controlled fatigue protocols, which do not accurately reproduce the conditions of an actual soccer match. Thus, the primary objective of this study was to analyze the effects of one-half of a soccer match on the functional capacity and stability of the lower limbs in young soccer players.

## MATERIALS AND METHODS

### Subjects

We analyzed 27 soccer athletes from the men's team at the Vila Guarani's Team Club (mean  $\pm$  standard deviation:  $16 \pm 0.83$  years old,  $1.7 \pm 0.08$  m,  $60.5 \pm 9.48$  kg,  $21.16 \pm 2.20$  body mass index (BMI),  $6.5 \pm 2.56$  years of practice). The inclusion criteria for this study included soccer players who were under the age of 18, were male, trained more than three times per week for at least nine hours per week and had participated in the sport for more than two years. The exclusion criteria included goalkeepers, the occurrence of knee and/or ankle injuries in the last six months, the presence of mechanical or functional instability of the knee and/or ankle, a history of prior orthopedic knee and/or ankle surgery or spine and/or hip injuries in the last six months and the presence of cerebellar disorders. Two athletes were excluded from the study: one player had a history of an ankle sprain within the previous six months, and the other player had an anterior cruciate ligament reconstruction in his right knee.

The athletes completed a questionnaire on their anthropometric characteristics, previous injuries, and soccer practice routine. The dominant lower limb was defined by the athlete as the leg that was predominantly used to kick the ball. The players were also subjected to a functional capacity evaluation of their lower limbs using a hop test protocol and an evaluation of their level of postural stability using the Biodex Stability System (Biodex Inc., Shirley, NY) before and immediately after a soccer match that lasted for 45 minutes. The athletes were evaluated during a series of 10 friendly matches held in the afternoon (3 pm) in June and July 2011.

### Procedures

**Hop Tests.** The athletes underwent the following tests: single hop test, triple hop test, crossover hop test, and timed hop test (Figure 1). The execution sequence for the tests of the lower limbs was randomized. Before the start of each data collection, two practice tests were conducted to familiarize the participants with the tests; these tests were then followed by three official tests for data collection. To perform the jumps, all of the participants were instructed to keep their arms crossed on their lumbar spine and jump while maintaining stability upon landing. For the single hop test, each participant jumped with one leg, attempting to jump as far as possible with a single jump. For the triple hop test, three consecutive jumps were performed with the same leg in an attempt to jump as far as possible. For the crossover hop test, the participant performed three consecutive jumps over a 15-cm line that had been marked on the floor. For the timed hop test, each participant jumped as fast as possible toward a previously determined mark 6 m away (8). In previous studies (9,10), the coefficients of interclass reliability for the tests were as follows: single hop test, .92 - .96; triple hop test, .95 - .97; crossover hop test, .93 - .96; and timed hop test, .66 - .92.

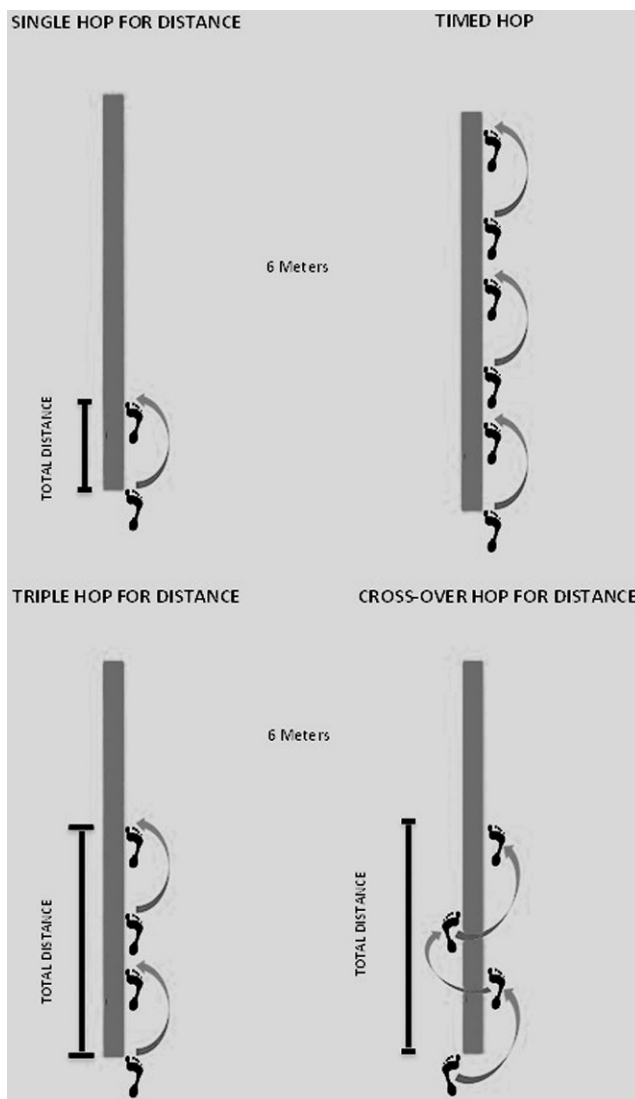


Figure 1 - Four hop tests.

### Level of postural stability

The Biodex Stability System (Biodex, Inc., Version 3.1, Shirley, New York, USA) was used to measure postural stability. The evaluation was performed for eight different levels of platform stability for a total of 30 seconds: level 8 was the most stable, and level 1 was the most unstable (consisting of 3.75 seconds at each level). This platform provides an objective assessment of postural stability using three indices: the overall stability index (OSI), the anterior-posterior stability index (APSI), and the medial-lateral stability index (MLSI) (Figure 2). These indices were calculated using the degree of oscillation of the platform, in which low values indicated that the individual had good stability (11). In a previous study, Salavat et al. (8) reported interclass reliability coefficients of .77 and .99 using the same methodology that was used in this study.

The test protocol performed was unipodal, consisting of two periods of adaptation to the device and three consecutive assessment tests. The participants were allowed to rest for 60 seconds between the tests. The testing order was randomized (dominant  $\times$  non-dominant), and the



**Figure 2** - An athlete performing the platform stability test.

athlete was positioned with his arms parallel to the longitudinal axis of the body while keeping his hand in contact with his thigh. The subject was instructed to keep his eyes open and fixed on a point on a white wall 1 meter from the equipment, and his knees were bent  $10^{\circ}$  to  $15^{\circ}$  while keeping his hips in a neutral position. After the three tests, the device software reported the stability index based on the degree of oscillation of the platform during the evaluations.

### Statistical analyses

Initially, we used a Kolmogorov-Smirnov test to verify the normality of the data. Then, we used a two-way ANOVA (2x2) with repeated measures to determine the differences between the legs (dominant and non-dominant) and between the different conditions (pre-game and post-game) for OSI, APSI, MLSI, and the four hop tests. The Bonferroni test was used for a post-hoc analysis when appropriate. A 5% level of significance was used ( $p < 0.05$ ), and the statistical analyses were performed using SPSS 17.0 software for Windows (Statistical Package for Social Sciences Inc., Chicago, IL, USA).

### Ethics

The study was submitted to and approved by the Ethical Committee at Federal University of São Paulo under protocol number 1635/10. All of the participants provided written informed consent.

### RESULTS

Using an ANOVA, we found a significant difference (moment  $\times$  leg) in the overall stability index (OSI)

( $F_{(1,23)} = 5.64$ ,  $p = 0.026$ ) and the anterior-posterior stability index (APSI) ( $F_{(1,23)} = 5.24$ ,  $p = 0.032$ ). However, there were no significant changes in the medial-lateral stability index (MLSI) or the four hop tests (Table 1).

The Bonferroni post-hoc test indicated that the dominant leg was responsible for the significant difference in the OSI ( $F_{(1,23)} = 5.52$ ,  $p = 0.014$ ) and APSI ( $F_{(1,23)} = 9.02$ ,  $p = 0.006$ ), whereas the non-dominant leg did not show any differences in the pre- and post-game comparisons. There was also a significant difference between the dominant and non-dominant leg in both the pre- and post-game situations in the single hop test ( $F_{(1,23)} = 7.15$ ,  $p = 0.015$ ) and the triple hop test ( $F_{(1,23)} = 4.53$ ,  $p = 0.047$ ) (Table 1).

### DISCUSSION

The principal findings of this study were the decreases in the overall and anterior-posterior stability indices of the dominant lower limb in young players after a soccer match. The results from previous studies on this subject, which were conducted using various populations, have been controversial (12-14).

In the elderly, some studies have shown that muscle fatigue in the lower limbs changes the sense of joint position and balance (13). Another study with a similar population showed no relationships between postural stability and performing moderate physical activity (12). The results from the current study demonstrate the importance of the intensity of the exercise on the muscles of the lower extremities when evaluating stability following exercise.

Gioftsidou et al. (15) demonstrated that there was no difference in the balance of young soccer players following a training session. Thus, these authors concluded that lower-limb muscle fatigue was likely not the cause for the increased incidence of injuries at the end of training sessions. In that study, however, the amount of time spent training was not specified, and the authors attributed the maintenance of balance following exertion to the absence of muscle fatigue after training. In contrast, our study found differences in the overall stability of these athletes following exertion. It is possible that the results were different due to the different loads that the subjects were exposed to and the

**Table 1** - Means and standard deviations of the stability indices and function tests in the pre- and post-game evaluations\*.

	Pre-Game		Post-Game	
	Dominant	Non-Dominant	Dominant	Non-Dominant
OSI (degrees) <sup>†</sup>	7.84 $\pm$ 1.6	7.21 $\pm$ 1.37	7.06 $\pm$ 1.53	7.21 $\pm$ 1.82
APSI (degrees) <sup>†</sup>	6.69 $\pm$ 1.79	6.06 $\pm$ 1.43	5.78 $\pm$ 1.56	5.93 $\pm$ 1.72
MLSI (degrees)	4.26 $\pm$ 0.93	4.15 $\pm$ 1.02	4.09 $\pm$ 0.9	4.19 $\pm$ 0.91
Single Hop (m) <sup>‡</sup>	1.75 $\pm$ 0.19	1.72 $\pm$ 0.18	1.74 $\pm$ 0.2	1.69 $\pm$ 0.16
Triple Hop (m) <sup>‡</sup>	4.92 $\pm$ 0.51	4.86 $\pm$ 0.42	4.9 $\pm$ 0.65	4.76 $\pm$ 0.61
Cross Hop (m)	4.33 $\pm$ 0.44	4.38 $\pm$ 0.6	4.33 $\pm$ 0.64	4.38 $\pm$ 0.68
Timed Hop (sec)	2.13 $\pm$ 0.27	2.07 $\pm$ 0.3	2.09 $\pm$ 0.2	2.12 $\pm$ 0.33

\*OSI, overall stability index; APSI, anterior-posterior stability index; MLSI, medial-lateral stability index.

<sup>†</sup>Significant difference ( $p < 0.001$ ) between the pre-game and post-game results for the dominant lower limb.

<sup>‡</sup>Significant difference ( $p < 0.05$ ) between the limbs.

different local climate conditions. In our study, all of the young players were evaluated before and after the first half of a soccer match, which was 45 minutes long, not following a training session. The study was conducted in São Paulo, Brazil, where the normal average temperature is higher than that in Greece (20°C vs. 16°C), which was the location of the cited study.

Other previous studies have also found that muscle fatigue of the lower extremities, particularly of the proximal muscle groups, affects postural stability (8,16). We did not find any differences in the overall stability with regard to the stability of the dominant leg compared to the non-dominant leg. Similar results were reported by Thorpe and Ebersole (17) and Teixeira et al. (18), who found no difference in the balance between the dominant and non-dominant legs in studies with 12 and 11 soccer players, respectively.

Another important finding in our study was the difference in the functional capacity between the dominant and non-dominant legs in the pre- and post-game comparisons for the single and triple hop tests. Swearingen et al. (16) presented similar findings in a study of healthy patients of both sexes who averaged 24 years of age (19). However, in a study of healthy subjects and sports players, van der Harst et al. (20) found no differences between the dominant and non-dominant legs in single hop test and timed hop test evaluations. However, in both of these studies, the tests were not conducted both before and after exercise.

Although we used four hop test evaluations, a recent study of non-surgically treated patients following the rupture of the anterior cruciate ligament demonstrated that the single hop test alone can be used as a predictor of knee functionality (21).

One weakness of our study was the lack of isokinetic evaluations to determine the degree of muscle fatigue imposed on the musculature of the lower limbs in athletes post-exercise. Another limitation of our study was the lack of standardization of the player's position. The effort of an athlete varies greatly depending on the position (for example, defender, midfielder, and forward in soccer), which can be considered a bias because the players were not exposed to the same physical stress. However, we chose to use a soccer match and evaluate the players at different positions to most closely align the characteristics of the study with how the sport is actually played.

The results of this study show that there is a decrease in the stability of the lower limbs in young soccer players after a 45 minutes soccer match. Another important finding was the functional capacity of the dominant leg compared to the non-dominant leg in the pre- and post-game comparisons in the single and triple hop tests.

## AUTHOR CONTRIBUTIONS

Yamada RK, Arliani GG, Almeida GP, and Venturine AM were responsible for the project conception, data collection, and manuscript writing. Dos Santos CR and Astur DC were responsible for the

bibliographic review, data tabulation, and statistical analysis. Cohen M critically revised the content of the manuscript.

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